MONTHLY PROGRESS REPORT
Slurry/Micro-Surface Mix Design Procedure
August 2005

To: T. Joe Holland, CALTRANS
Contract No.: CALTRANS 65A0151
Contractor: Fugro Consultants LP
Contract Period: June 30, 2003 – Nov. 30, 2007
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PROJECT OVERVIEW

The overall goal of this research is to improve the performance of slurry seal and micro-surfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

Phase I of the project has two major components: 1) the first consists of a literature review and a survey of industry/agencies using slurry and micro-surfacing systems, 2) the second deals with the development of a detailed work plan for Phases II and III.

In Phase II, the project team will evaluate existing and potential new test methods, evaluate successful constructability indicators, conduct ruggedness tests on recommended equipment and procedures, and prepare a report that summarizes all the activities undertaken under the task.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines. All activities of the study will be documented in a Final Report.

NOTE: New information for the current month is notated by double-lines to the left of text, tables, or figures.

PHASE I—LITERATURE SEARCH AND WORK PLAN DEVELOPMENT

Task 1 Literature Review and Industry Survey—Completed

The literature review process is complete with all sources of information on the design and use of micro-surfacing and slurry seals reviewed and summarized in Chapter 2 of the Phase I Report. The three survey questionnaires were included in the August 2003 monthly report and the results were summarized in the Phase I Report.

Task 2 Work Plans for Phases II and III—Completed

The Phase II Work Plan was included in Chapter 3 of the Phase I Report. The Phase III Work Plan was included in Chapter 4 of the Phase I Report.
All activities of Phase I are complete. The results are included in the Phase I Interim Report that was submitted to CALTRANS in March 2004.

PHASE II—MIX DESIGN PROCEDURE DEVELOPMENT

Tasks 3 & 4—Evaluation of Potential Test Methods & Successful Constructability Indicators

The evaluation activities of Tasks 3 and 4 concentrated on the following areas:

a) Classification of ISSA TB113 test results to allow correlation with the new Automated Mixing Test (AMT).
b) Development of Automated Mixing Test (AMT): geometry, stirrer, stirrer speed, cups, and software. The AMT was referred earlier in the project as the "German Mixing Test".
c) Development of the Cohesion Abrasion Test (CAT). This test was formally referred in the project as the French WTAT or FWTAT.
d) Assessment of other factors such as stripping.
e) Application of AMT and CAT to compare different slurry systems
f) Modify initial proposed testing factorial to account for the findings of steps a) through e)

Materials

Four mixes have been used in this phase of the evaluation study:

- Mix 1 LMCQS-1h + Table Mountain Aggregate
- Mix 2 LMCQS-1h + Lopke Gravel Aggregate
- Mix 3 Ralumac + Table Mountain Aggregate
- Mix 4 Ralumac + Lopke Gravel Aggregate

Testing of the Table Mountain and Lopke Gravel Aggregates is complete. Tests included sieve analysis, sand equivalent, Los Angeles abrasion, and sodium sulfate soundness testing. The results were noted in previous progress reports. The aggregates were forwarded to Valley Slurry Seal and Koch Materials for the formulation of the emulsions.

The sodium sulfate testing was re-done because an old solution was used for the initial testing and there was some concern that the results might not be valid. The results were included in Attachment A of the August 2004 progress report.

The standard suite of ISSA mix design tests was performed on the mixtures using Ralumac emulsion to establish "benchmarks" before progressing to the new and modified test procedures. The results were included in Appendix A of the November 2004 progress report.

Significant progress was made during the month of August in evaluating the new/proposed test procedures, as described in what follows:

Revised ISSA TB113 Test

In this test, trial mixes are made in disposable cups. The components are mixed by hand. As a modification to the original ISSA protocol, the trial mixes are divided in several categories to identify mixes to be used in the Automated Mixing Test. These categories are:

S	Soupy: brown free liquid on surface, segregating sample
LV	Low Viscosity: consistency runny but not segregating; easy to mix
MV	Moderate Viscosity: non-segregating mix, moderate resistance to mixing considered; good consistency
ST	Stiff: hard to mix but workable
B	Broken: lumps, not consistent

Blot Test

Following the evaluation study, the research team recommends that a 30 second blot test be performed after the trial mixing. The blot test is included in ISSA TB 102. The results of the blot test are summarized as follows:

BT	Brown/black transfer of emulsion binder
A	Agg and clear
CW	Clear water

Based on the results of these two tests (TB 113 and the blot test), only the best mixtures are chosen for the Automated Mixing Test (AMT). These mixtures are classified as:

- LV or MV from TB113

  AND
- CW from the blot test

Automated Mixing Test (AMT)

The new mixing test is fully functional and a series of tests have been performed to evaluate the equipment and procedure. The apparatus is shown in Figure 1

FIGURE 1 New Mixing Test

The AMT measures the build up of cohesion with time. Three parameters are derived from the test:

1. Mix Index = torque resistance measured during the initial stage of mixing

2. Mix Time = time for which mixing continues without a significant increase in torque/cohesion
3. Spread Time = time over which the torque/cohesion increases from the Mix Index value to 12 N-cm (set torque).

A plot of torque versus time illustrating the parameters derived from the AMT test is given in Figure 2. Note that the trace for calculating the Spread Time is not complete in this screen capture:

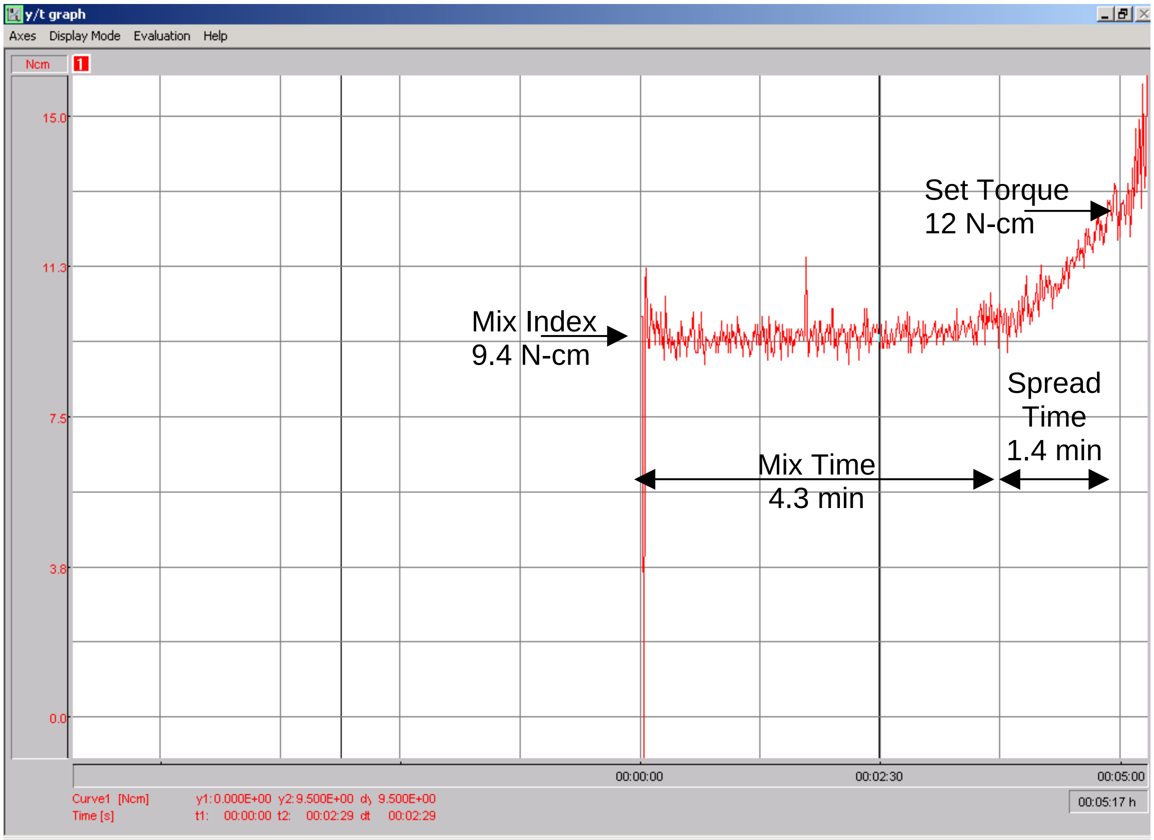

FIGURE 2 AMT Test Readout

The test allows measurement of mix characteristics reproducibility, it allows traces to be based on rheological type as per TB113 or system type – micro or quick set slurry. Correlation with mix characteristics from TB113 allows determination of which mixes will be useable or not. Use of the test in a temperature controlled environment or preparation of emulsion and aggregate at different temperatures simulates mixing under different conditions. The test may also be used to optimize mix ratios and prepare a field guide for the effect of additive and temperature as well as water levels permitted to avoid segregation.

Setting and Curing Test

The Setting and Curing Test is performed with a modified Wet Cohesion Tester. However, this piece of equipment consistently failed to operate as planned and it was concluded that a different manufacturer be contacted to modify the desired apparatus. The development effort is continuing. We anticipate that a prototype model will be available by the end of September.

Cohesion Abrasion Test (CAT)

The Cohesion Abrasion Test was formerly referred to as the French wet track abrasion test (FWTAT). The purpose of the test is to determine the curing characteristics of the mixture with time, curing conditions, and water sensitivity. It can also be used to determine the minimum binder content of the mix. The apparatus and a detail of the wheel fixture are shown in Figure 3.

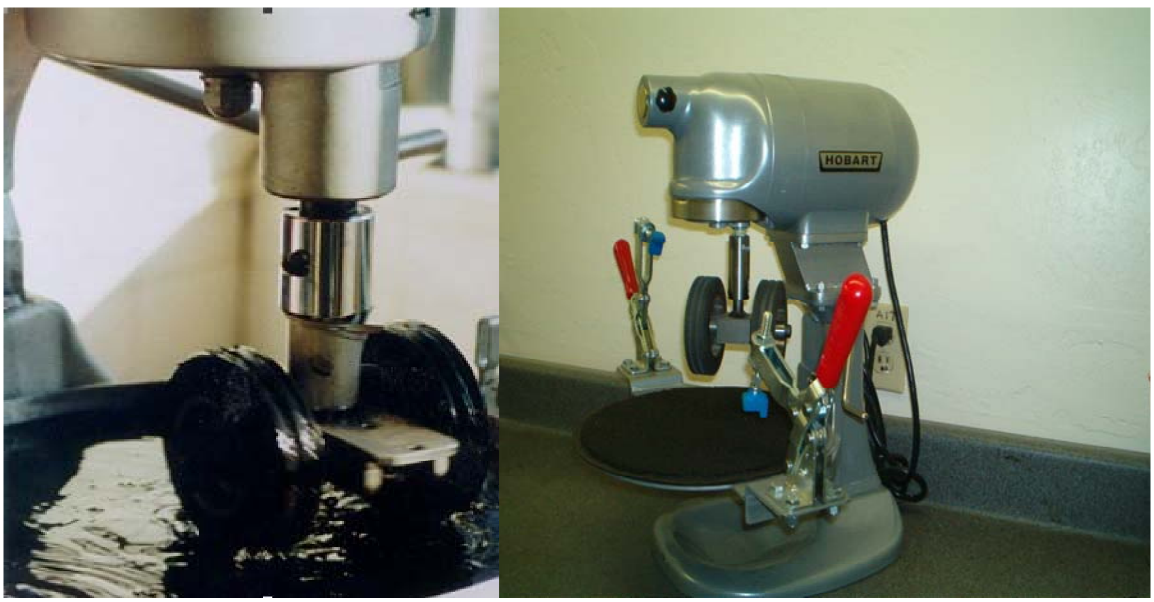

FIGURE 3 CAT Test – Setup and Detail of Wheel Fixture

After a full assessment of potential modifications and conditions the following testing protocols were selected:

1. The ratios of mix components for testing are chosen from tests successful in TB113 and AMT
2. Samples are made up with 1.2kg of aggregate NO scalping is done
3. The mold as described in the French test is used 6.35mm deep and 254mm in diameter. A Hobart N50 mixing device is used.
4. The samples are stuck off with dowel
5. 1 sample is cast on pre-weighed roofing felt (30lb)
6. Test samples are cast on pre-weighed stainless steel or aluminum plates diameter 320mm in diameter, 2mm thick. A light tack is applied to the plate.
7. Samples are cured as follows: 30 minutes, 1 hr, 3 hr and 5 hrs
8. The sample on roofing felt is cured for 12 hrs at 60C; this becomes the dry weight
9. The samples cured for other times may be cured at different humidity and temperature conditions

10. Samples cured for 30 minutes, 1 hr and 3 hours are placed in the pan of the N50 and the stage is raised to make contact with the wheels so the full weight of the jig is supported by the sample. The area of abrasion is 207.1 cm^2.
11. The sample is covered with water to 5mm above the sample height
12. The sample is abraded for 60 seconds on speed 1 of the N50
13. The sample is immediately removed form the machine and washed with 1 L of water. More may be needed to ensure that all the material removed in the abrasion is washed away.
14. The sample is then patted dry of excess moisture with paper absorbent towels. The type of failure is observed; the sample is then placed in an oven at 60C for 12 hrs - 16 hrs.
15. The 5 hr cure samples are soaked for 1, 3 and 24 hrs and testing is done as for 10 -14 above.
16. Loss is computed on a dry basis as g/cm2.

Depending on the measured abrasion loss, the slurry systems are classified as:

High Cohesion	0 – 0.48 g/cm^2 for samples cured 1 to 3 hrs
Moderate Cohesion	0.5 – 1.45 g/cm^2
Low Cohesion	> 1.5 g/cm^2

A time to cohesion can be computed at the conditions of cure where loss is 0.48g/cm^2 or less. Lost stone is examined for coating of binder and % stripping assessed. More details on the test development activities will be included in the Phase II Report.

Draft test protocols for the AMT and CAT tests will be included in the next monthly report.

Draft Specification

A first draft of the specification has been developed during the last reporting period. Traffic, temperature, humidity and the desired set time dictate the threshold values to be met by a particular slurry system. Table 1 summarizes the mix characterization tests to be performed and the acceptable limits for the properties measured.

Task 5—Ruggedness Tests of Recommended Equipment and Procedures

In comparison with the testing in Tasks 3 and 4, the tests of Task 5 will be performed at a single set of temperature, humidity, and cure time conditions. "Standard" conditions were chosen by the team (e.g., 50 percent humidity, 25°C temperature). Slight variations in these parameters will be allowed to evaluate the ruggedness of the test procedures. The team is currently reviewing the test factorials proposed in the Phase II Work Plan.

Task 6—Phase II Report

No Activity

TABLE 1 Draft Specification

Set Time	Test or field Condition	Units	Traffic Hi	Traffic Med	Traffic Low	Temperature Hi 35 C	Temperature Med 25 C	Temperature Low 10 C	Humidity Hi 90%	Humidity Normal 50%
Rapid	***Automated Mixing Test (AMT)***									
	Mixing Torque - maximum	*N-cm*	9	9	9	9	9	9	9	9
	Mixing time - minimum	*sec.*	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120 sec.	*N-cm*	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	-	clear water	clear water	N/A	clear water	clear water	clear water	clear water	clear water
	Coating	-	100%	100%	95%	95%	95%	100%	100%	95%
	Automated Cohesion Test									
	30 min. cohesion - minimum	*N-cm*	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	*N-cm*	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	*N-cm*	25	25	25	25	25	25	25	25
	12 hr. cohesion - minimum	*N-cm*	28	28	28	28	28	28	28	28
	Cohesion Abrasion Test (CAT)									
	30 min. loss - maximum	g/m^2	200	200	400	300	300	300	300	300
	1hr. loss - maximum	g/m^2	100	100	300	100	200	100	100	200
	3 hr. loss - maximum	g/m^2	100	100	200	100	100	100	100	100
Slow	***Automated Mixing Test (AMT)***									
	Mixing Torque - maximum	*N-cm*	9	9	9	9	9	9	9	9
	Mixing time - minimum	*sec.*	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120 sec.	*N-cm*	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	-	clear water	clear water	N/A	clear water	clear water	clear water	clear water	clear water
	Coating	-	100%	100%	95%	95%	95%	100%	100%	95%
	Automated Cohesion Test									
	30 min. cohesion - minimum	*N-cm*	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	*N-cm*	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	*N-cm*	25	25	25	25	25	25	25	25
	12 hr. cohesion - minimum	*N-cm*	28	28	28	28	28	28	28	28
	Cohesion Abrasion Test (CAT)									
	30 min. loss - maximum	g/m^2	200	200	400	300	300	300	300	300
	1hr. loss - maximum	g/m^2	100	100	300	100	200	100	100	200
	3 hr. loss - maximum	g/m^2	100	100	200	100	100	100	100	100

PHASE III— PILOT PROJECTS AND IMPLEMENTATION

Task 7—Development of Guidelines and Specifications

A list of references that contain guidelines and specifications has been drafted and is noted below:

- ISSA A105 Guidelines for Slurry—Available
- ISSA A143 Guidelines for Micro-Surfacing—Available
- TTI Report 1289-2F Use of Micro-Surfacing in Highway Pavements—Available.
- Report contains:
    - Methods and Materials Specifications
    - Quality Control and Assurance Tests (including field cohesion and vane shear tests)
    - Quality Control Guidelines (including materials acceptance tests and mixture design verification)
    - A Checklist
    - Usage Guidelines.
- ISSA Inspector's Manual—Available
- Caltrans Maintenance Technical Advisory Guide Final Draft—Available
- The ISSA Workshop Folder—Available

The guidelines and specifications will be a concise collection, presented in AASHTO format. This is one area of Phase III where the team can work at present. At the end of Phase II, the document will be appended with findings and recommendations relative to the new tests developed in Phase II.

Task 8—Workshop Training Program/Pre-Construction Module

The team agreed that work could commence in several chapters of the Reference Manual to be developed under this task. The Reference Manual will be a comprehensive, textbook-like document with background information, explanations, and pertinent information on the design and use of slurry systems.

A first draft of the Reference Manual is now available and is included in Appendix A of the progress report.

Task 9—Pilot Projects/Procedure Validation

The team developed guidelines for selecting pilot projects to be used by State agencies. The proposed pilot project layout contains six different sections:

- A control section placed using the ISSA current procedure.
- A bare section (do nothing)
- Improved mix design (using the method developed in Phase II), Replicate 1
- Another contractor-based control (ISSA design).
- Another bare section.
- Improved mix design (using the method developed in Phase II), Replicate 2

The final version of the Guidance Document was included in Appendix A of the October 2004 and April 2005 progress reports. The document was forwarded to the participant State agencies and other agencies interested in participating in the pilot project study.

Task 10—Final Report

No Activity

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below.

- Videoconference scheduled for September 15, 2005
- Coordinate with CALTRANS personnel on an as-needed basis.
- Continue with Phase II and Phase III activities.

PROBLEMS / RECOMMENDED SOLUTIONS

All problems with the acquisition of the test equipment have been overcome. Significant progress has been made during the month of August.

FINANCIAL STATUS

The Financial Summary Table shows the estimated expenses incurred during the reporting period and to the present from the inception of the contract. Testing has been removed as a separate Cost Element item because it is a subcontractor task activity.

The Financial Summary Chart illustrates total expenditures by month for the project.

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APPENDIX A
DRAFT REFERENCE MANUAL

SLURRY/MICRO-SURFACING SYSTEMS MIX DESIGN

REFERENCE MANUAL

DRAFT 3

September 14, 2005

CHAPTER 1 INTRODUCTION

1.0 BACKGROUND

Highway agencies throughout the world are responsible for safe and reliable pavement systems in order to efficiently move people and goods. As new and rehabilitated pavements are subjected to traffic and the environment, they begin to show signs of distress that are typically cracking and rutting and loose some of their desired functional features such as smoothness and friction resistance. At some stage in the pavement deterioration cycle, the agency usually applies some treatment to prevent further damage. When placed early in the life of the pavement, these treatments are considered preventive maintenance and are part of a larger agency program referred to as pavement preservation. The same treatments can be placed to correct an unsafe condition and when this is referred to as corrective maintenance.

Two treatments that are used worldwide for both corrective and preventive maintenance of pavements are slurry surfacing and micro-surfacing. As will be seen, the design procedures for these pavement systems have been developed over the last 50 years and although in some instances they work as intended, in other cases designs prepared in the laboratory don't perform as intended when placed. There are a number of reasons for this situation but one of the principal reasons is that the existing design procedures don't relate to performance.

As a result, a number of AASHTO states, the Federal Highway Administration, and Industry jointly pooled their funds to support a study to develop an improved slurry surfacing and micro-surfacing mix design procedure. This reference manual was prepared by the study team as a part of a training program to provide the basics on the development and application of the improved mix design procedures.

1.1 HISTORICAL DEVELOPMENTS

Slurry seals were developed and used for the first time in Germany, in the late 1920's.(1) At that time, the product consisted of a mixture of very fine aggregates, asphalt binder, and water, and was mixed by introducing the components into a tank outfitted with an agitator. It proved to be a novel approach, a new and promising technique for maintaining road surfaces, and marked the beginning of slurry seal development. However, it was not until the 1960's, with the introduction of improved emulsifiers and continuous flow machines, that real interest was shown in the usage of slurry seal as a maintenance treatment for a wide variety of applications: from residential driveways to public roads, highways, airport runways, parking lots, and a multitude of other paved surfaces.(2)

Micro-surfacing was pioneered also in Germany, in the late 1960's and early 1970's.(1) German scientists were looking for a way to use conventional slurry in thicker applications that could be applied in narrow courses to fill wheel ruts, and not destroy the expensive road striping lines on the autobahns. Micro-surfacing was the result of combining highly selected aggregates and bitumen, and then incorporating special polymers and emulsifiers that allowed the product to remain stable even when applied in multi-stone thicknesses. Micro-surfacing was introduced in the United States in 1980, as a cost-effective way to treat the surface wheel-rutting problem and a variety of other road surface problems.(1)

There is a need to develop new mix design procedures, guidelines, and specifications for slurry seal and micro-surfacing that address performance needs of the owners and users, the design and application needs of the suppliers, and improve the reproducibility of the test methods used for the current mix design procedures. The existing International Slurry Seal Association (ISSA) procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143) and the corresponding American Society for Testing and Materials (ASTM) Standards D3910 and D6372 have their origin in the 1980's before the widespread use of micro-surfacing and the use of polymer modified emulsions in slurry seals.(3-6) These test methods and design procedures remain in use today because there is no test method or mix design procedure that specifically addresses micro-surfacing and the adequate representation/characterization of its performance indicators. While differences exist between slurry seal and micro-surfacing applications (i.e., traffic volume, application thickness, and curing mechanisms), the similarities of the tests currently used indicate that the two systems must be studied together.

As a result of the work accomplished in this study, the above noted concerns have been addressed.

1.3 WHY SLURRY SYSTEMS

1.4 THE FUTURE OF SLURRY SYSTEMS

1.5 OBJECTIVES AND SCOPE OF THE MANUAL

The objective of the manual is to be a "stand alone" document that covers all the key aspects of the improved mix design procedure. It will be used as the basic text book for the training course and provide the participants with a technical resource in the future. It is designed for several levels of users ranging form pavement designers to field inspectors and contractor personnel.

The scope of the manual deals with the following issues:

- Determining the suitability of a project in order to get the optimum performance from the mixture

- The pre-construction requirements that need to be addressed
- Specifications
- The mix design criteria
- Test methods and procedures
- Construction considerations and limitations
- Construction operations
- QC/QA Requirements
- Troubleshooting
- References
- Appendices with test methods and specifications

Each of these areas will be covered in the chapters that follow

1.6 ORGANIZATION OF MATERIAL

CHAPTER 2 SLURRY SYSTEMS REVIEW

2.1 WHAT IS SLURRY SEAL

Slurry seal is a mixture of emulsified asphalt, aggregate, mineral filler, and water that is mixed and spread over a properly prepared pavement surface. In some instances, polymers are also added to slurry seals.

Slurry seal is a cost-effective thin, cold surfacing that is used to extend the life of the existing pavement surface by protecting the surface from environmental degradation [oxidation and moisture]. There are three different gradations of slurry that are commonly used and these are noted in Table 1[(1)]. They range from fine [-2.36 mm] to coarse [- 9.5 mm], the finer mixes are used for maximum crack sealing and in low traffic areas and the coarser mixes are used for minor surface corrections and heavy traffic.

TABLE 1 Slurry Seal Gradations

Sieve Size	Type I % Passing	Type II % Passing	Type III % Passing
9.5 mm	100	100	100
4.75 mm	100	90-100	70-90
2.36 mm	90-100	65-90	45-70
1.18 mm	65-90	45-70	28-50
600 µm	40-65	30-50	19-34
330 µm	25-42	18-30	12-25
150 µm	15-30	10-21	7-18
75 µm	10-20	5-15	5-15

Slurry Seal mixtures are designed in the laboratory using a mix design procedure recommended by the International Slurry Surfacing Association [ISSA] [(1)] and placed on the pavement surface with a specially designed paver that proportions and mixes all the ingredients and places the mix in a spreader box, which distributes and strikes-off the mixture on the pavement surface. The continuous flow mixing chamber on the paver is a ribbon-type spiral mixer that blends the ingredients into a homogeneous mix that flows into the spreader box.

2.2 WHAT IS MICRO-SURFACING

Micro-surfacing is similar to slurry seal in that the mix components are asphalt emulsion, aggregate, mineral filler and water. In addition, polymers and chemical additives are normally included in the mixture along with high quality aggregate, making micro-surfacing an ideal mixture for surfacing heavily trafficked pavements and for correcting rutted surfaces. Traffic can normally be returned to the pavement within an hour after placement.

There are two gradations commonly used for micro-surfacing although individual agencies may have more than two. The gradations are noted in Table 2 (2) and range from fine [- 4.75 mm] to coarse [- 9.5 mm].

TABLE 2 Micro-surfacing Gradations

Sieve Size	Type II % Passing	Type III % Passing
9.5 mm	100	100
4.75 mm	90-100	70-90
2.36 mm	65-90	45-70
1.18 mm	45-70	28-50
600 µm	30-50	19-34
330 µm	18-30	12-25
150 µm	10-21	7-18
75 µm	5-15	5-15

Equipment similar to that used in slurry seals is used to mix and place micro-surfacing, however, since the mixture is designed to break quickly and is much stiffer than a slurry mixture, a pugmill instead of a ribbon-type mixture is standard equipment on micro-surfacing machines. The spreader box has an initial strike-off device and most of the newer boxes have a secondary strike-off that enhances the final surface texture. Since micro-surfacing is also used to fill ruts, a specially designed rut box is used for this application. This box delivers the coarser aggregate particles to the deepest part of the rut to provide maximum stability to the filled rut.

Micro-surfacing mixtures are designed in the laboratory using a mix design procedure recommended by the International Slurry Surfacing Association [ISSA] (2)

2.3 SLURRY SYSTEMS OVERVIEW

Slurry seals were developed and used for the first time in Germany, in the late 1920's.(3) At that time, the product consisted of a mixture of very fine aggregates, asphalt binder, and water, and was mixed by introducing the components into a tank outfitted with an agitator. It proved to be a novel approach, a new and promising technique for maintaining road surfaces, and marked the beginning of slurry seal development. However, it was not until the 1960's, with the introduction of improved emulsifiers and continuous flow machines, that real interest was shown in the usage of slurry seal as a maintenance treatment for a wide variety of applications: from residential driveways to public roads, highways, airport runways, parking lots, and a multitude of other paved surfaces.(4)

Micro-surfacing was pioneered also in Germany, in the late 1960's and early 1970's.(5) German scientists were looking for a way to use conventional slurry in thicker applications that could be applied in narrow courses to fill wheel ruts, and not destroy the expensive road striping lines on the autobahns. Micro-surfacing was the result of combining highly selected aggregates and bitumen, and then incorporating special polymers and emulsifiers that allowed the product to remain stable even when applied in multi-stone thicknesses. Micro-surfacing was introduced in the United States in 1980, as a cost-effective way to treat the surface wheel-rutting problem and a variety of other road surface problems.(6)

Despite the widespread use of slurry seals and micro-surfacing, current tests and design methods are primarily empirical and are not related to field performance. There is very limited knowledge on the relationships among certain test parameters, environmental factors, and mix performance in the field. Thus, there is a need to develop new mix design procedures, guidelines, and specifications for slurry seal and micro-surfacing that address performance needs of the owners and users, the design and application needs of the suppliers, and improve the reproducibility of the test methods used for the mix designs. The current International Slurry Seal Association (ISSA) procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143) and the corresponding American Society for Testing and Materials (ASTM) Standards D3910 and D6372 have their origin in the 1980's before the widespread use of micro-surfacing and the use of polymer modified emulsions in slurry seals.[(7-10)] These test methods and design procedures remain in use today because there is no test method or mix design procedure that specifically addresses micro-surfacing and the adequate representation/characterization of its performance indicators. Recent Texas Transportation Institute (TTI) studies documented the problems associated with using the existing methods for micro-surfacing and suggested the development of a comprehensive mix design and analysis procedure.[(11)] While differences exist between slurry seal and micro-surfacing applications (i.e., traffic volume, application thickness, and curing mechanisms), the similarities of the tests currently used indicate that the two systems must be studied together.

CHAPTER 3 PROJECT SELECTION CRITERIA

CHAPTER 4 MIX DESIGN

4.1 MIX DESIGN FLOWCHART

4.2 BINDER REQUIREMENTS

4.3 AGGREGATE REQUIREMENTS

4.4 BLENDING REQUIREMENTS

4.5 TEST METHODS

4.6 MIX DESIGN EXAMPLES

CHAPTER 5 SYRAMID SPECIFICATIONS

CHAPTER 6 CONSTRUCTION CONSIDERATIONS AND LIMITATIONS

6.1 PROJECT GEOMETRY

6.2 WEATHER LIMITATIONS

Depending on the type of mix (conventional slurry seals, quick sets, or microsurfacing), pavement temperatures, ambient temperatures, and moisture all can affect the successful construction of a slurry. Higher pavement temperatures (and ambient temperatures) will accelerate the slurry set; lower temperatures can actually slow the set down. Under extremely hot conditions, the use of spray bars to fog the pavement surface will help to cool the surface and prevent the emulsion from breaking on contact with the surface. High temperatures may also require that water be added to the mix to control the tendency of the mix to lose water, but this is not good practice. Cold temperatures are also a concern for slurries. When exposed to freezing temperatures, water in the mix will freeze and destroy the slurry.

The following temperature and weather guidelines are recommended:

- Do not place slurry surfacings when there is a possibility of temperatures at or below 0 °C (32 °F) within 24 hours of construction.
- Do not place slurry surfacings if either the pavement or air temperature is below 15 °C (50 °F) and falling.
- Slurry surfacings can be constructed if the temperature is above 7 °C (45 °F) and rising.
- The higher the humidity, the slower the evaporation process and the longer the set time. Slurries without a chemical set should not be placed when the humidity is excessively high or when rain is expected within several hours.
- No slurry should be constructed in foggy or rainy weather.

CHAPTER 7.0 CONSTRUCTION OPERATIONS

7.1 EQUIPMENT AND CALIBRATION REQUIREMENTS

Prior to construction, the equipment must be calibrated so that the machine delivers the mix in the desired proportions. Recall that those proportions have already been established in the mix design process, and now the contractor must adjust the equipment so that it meters out the proper amount of aggregate, emulsion, and additives to match the design. Equipment calibration is a fairly simple process, requiring a truck loaded with the mix aggregate and emulsion, a place to offload or discharge the aggregate, a truck scale to weigh the loaded truck, a scale to weight the cement, and a container to catch the cement. The moisture content of the aggregate must also be calculated.

The calibration process is described in detail in technical information available from ISSA. As an overview, it involves determining the amount of emulsion, filler, and aggregate to meter out to create the desired mix. The metering systems are tied to the aggregate transport belt, and are based on measuring the material quantities that are delivered per revolutions of the head pulley that moves the belt. In most systems, quantities of aggregate are varied by altering the gate height that controls aggregate delivery to the belt. The delivery of the materials is measured by calculating quantities per "count." The aggregate is then run through the gate at three different heights to generate a curve of weight of aggregate versus gate height, and the mix design then is used to determine the actual gate height setting.

The equipment should be calibrated prior to the start of the construction season. It then does not need to be calibrated for each job, but nor should it go an entire season without calibration. Some general guidelines are that a calibration should be made according to the following schedule: a) every time materials are changed, b) every time parts are changed on the machine, and c) if neither (a) nor (b) occurs, two to three times per paving season.

7.2 SURFACE PREPARATION

Prior to the placement of a slurry seal or microsurfacing treatment, the entire surface should be cleaned of vegetation, loose debris, silt, and any other material that might prevent the slurry from either adhering or performing well. Appropriate cleaning methods include power sweeping (preferred), air blasting, and water flushing, although care should be taken with water flushing because allowing water into the base just prior to sealing the pavement surface will cause poor performance. When sweeping, material pick-up is required on curb and gutter sections so that dirt and other debris are not reintroduced to the pavement surface.

All organic material must be removed from the pavement surface, and any spots of grease or oil must also be removed. Water blasting, grinding, burning, and industrial detergents are all used to remove undesirable surface contaminants. A tack coat may be necessary if the surface is unpaved or extremely oxidized. A tack coat is also necessary to ensure that adequate adhesion is developed between a slurry and a concrete or brick pavement. The same emulsion used in a slurry seal should be used in the tack, and it is mixed at a ratio of three parts of water to one part emulsion, applied at a rate between 0.2 to 0.5 l/m^2 (0.05 to 0.10 gal/yd^2). If a tack coat is required for microsurfacing, the use of a CSS or SS emulsion is common.

Additional considerations prior to starting the surfacing process include the following:

- In-pavement features. All manholes, valve covers, and other in-pavement fixtures need to be located and protected prior to paving. They can be covered with paper or felt, which is then removed after paving. The paving crew should work around any concrete valleys.
- Pavement markings. Slurries do not adhere well to traffic tape, thermoplastics, or new striping. These should be removed prior to paving.
- Raised markers. These may be either removed and replaced, or covered. Alternatively, they may be paved over and then cleaned immediately after paving, although this can be problematic. Any successful method is likely to be labor intensive.
- Railroad tracks. Slurry placement should stop at the edge of the railroad right away. Slurry should never be allowed to be placed on or near railroad tracks.

7.3 SLURRY PLACEMENT

This section introduces some of the more detailed activities associated with the actual slurry placement process. It included discussions of traffic control issues, appropriate weather conditions, equipment calibration, spreader box setup, slurry placement, and rolling (if necessary).

7.3.1 Traffic Control

When slurries are placed on local roads, providing advance notice to the public of the upcoming work is strongly recommended. The notice should inform the public that the road will be closed to all vehicles for a specified period of time (usually 1 day). The notice should also specifically ban allowing water (from sprinklers, for example) to flow onto the street or into the gutters on the day of paving, and warn against allowing children or pets to walk on the fresh slurry.

7.3.2 Spreader Box Setup

The spreader box delivers the slurry from the machine over the pavement surface. While the equipment calibration process results in the machine producing the mix in the proper proportions, calibrating the spreader box results in the product delivered on the road at the desired application rate and with the desired final texture. Spreader boxes come in many sizes and with many different features, ranging from simple, non-adjustable units to large boxes equipped with augers, special runners, and hydraulic controls. Specialized boxes are always required for rut filling and variable-width spreading.

The primary difference between slurry seal and microsurfacing equipment is in the spreader box. The spreader box used for slurry seals is essentially a drag box pulled behind the paver, and may or may not include augers to spread the material and keep it agitated. On projects in which the spreader box is extended or where the pavement has significant cross slopes or uphill stretches, augers are essential. Augers are also essential with stiff mixes, such as all microsurfacings. Microsurfacing boxes are further differentiated from slurry seal boxes in that they are fixed to the paver, have two sets of augers, and a texturing rubber is used to finish the surface.

Good practice for maintaining and operating spreader boxes includes inspecting and cleaning the box daily prior to construction to remove any dried slurry, and replacing any worn rubber side skirts or screeds. In operation, the box should be neither overfilled nor underfilled. There should be enough mix in the spreader box so that the leading edge of the mix in the box rolls forward, but not much more. Especially with a quick-set slurry seal system, a minimal amount of material should be carried in the box.

An application rate is determined for each project, based on the following factors:

- Aggregate size (slurry type).
- Road surface texture.
- Primary strike-off downward pressure.
- Height of slurry in box.
- Adjustable strike-off.

ISSA's TB 112, *Method to Estimate Slurry Seal Spread Rates and to Measure Pavement Macrotexture*, describes a procedure that can be followed to adjust spread rates based on actual conditions (ISSA 1990c). Typical application rates are shown in table XXX. Where the actual gradation falls within the range for a given slurry type affects the required application rate: larger gradations are applied thicker in order to ensure that there is adequate embedment of the largest stone, while finer gradations must be applied thinner. Surface texture factors that affect the application rate are shown below:

- Surface void content.
- Extent of raveling.
- Extent of oxidation.
- Presence of minor rutting.

It is also important to note that pavement surface texture can vary on the same project both laterally and longitudinally, and therefore adjustments to the application rate may be required throughout the day.

The application rate is calculated by measuring the weight of slurry applied to the pavement surface and dividing it by the covered pavement surface area.

$$Application\ Rate = \frac{Weight\ of\ slurry, kg\ (lb)}{Area\ of\ pavement, m^2\ (yd^2)} \qquad \text{(Eq. 7-1)}$$

7.3.2.1 Primary Strike-Off

Rubber or urethane strips at the front and rear of the spreader box contain the mix; strips on the side are also used if the mix is particularly fluid. Usually the surface texture is imparted by a rubber strip used as the primary strike-off, as shown in Figure 7.3-1. Downward pressure is applied so that the strike-off is bent in a “J” shape, and the final thickness of the slurry is between 1 and 1.5 times the thickness of the largest stone in the mix. Adjustments to the application can be made by changing the height of the strike-off, the rubber hardness, and the length of the trailing rubber.

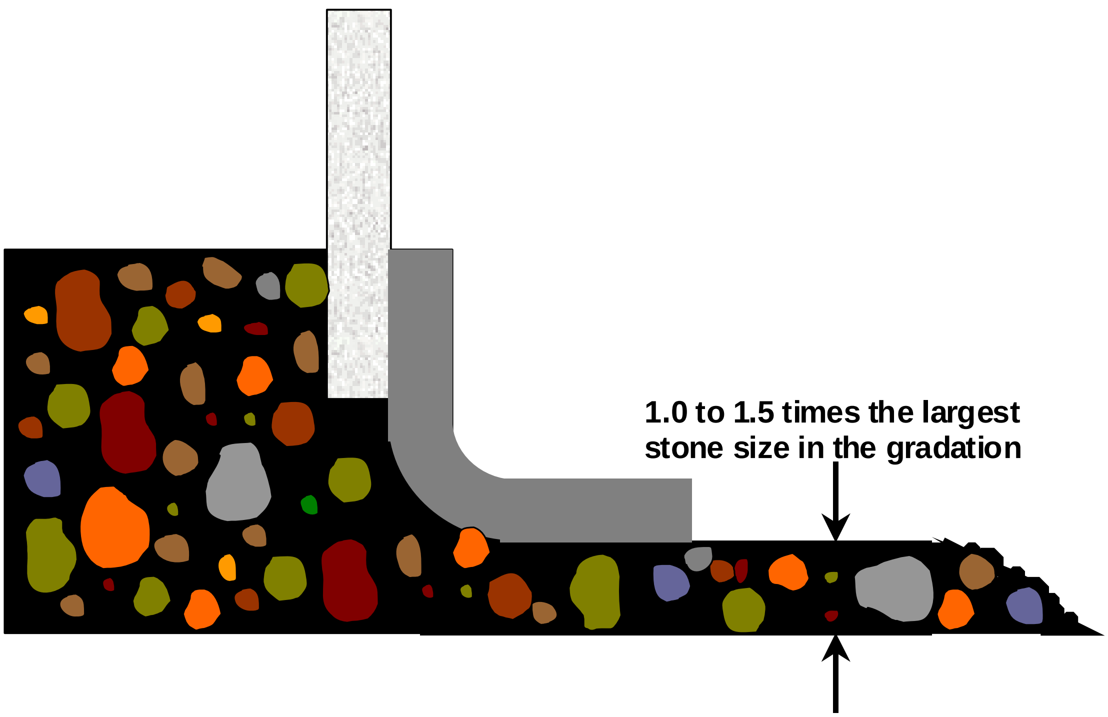

FIGURE 7.3-1 Primary strike-off of slurry mix.

7.3.2.2 Secondary Strike-off

A secondary strike-off is optional, but when used its function is to smooth out the final surface by removing ripples, and minor drag marks. This strike-off is fixed to the rear of the spreader box, and is used to apply the final surface texture. It can be burlap, although with some quick set (QS) mixes, burlap doesn't work because the slurry will set up on the burlap and leave drag marks. In such cases, either rubber or urethane secondary strike-offs are used.

7.3.3 Placement of Material

7.3.3.1 Slurry Seals

Prior to the placement of a slurry seal, local conditions may require that the surface be lightly dampened by fogging with water ahead of the spreader box (TAI 1997). During the application, no lumping, balling, or unmixed aggregate should be visible in the spreader box. Enough material should be carried in all parts of the spreader box so that complete coverage is attained (TAI 1997). However, care should be taken to not overload the spreader box.

Joints are a potential weakness in the surface, as well as an aesthetic problem. Transverse joints at the beginning and end of each street are created by placing tar paper on the surface being slurried, and removing it after the equipment has passed. Intermediate joints do not require any special procedures except, perhaps, with Type III mixes, where the larger stones may require a butt joint to provide a smooth transition. For longitudinal joints, the goal is to create a seamless, invisible transition. The recommended practice is to first minimize the number of longitudinal joints and next place them at the lane lines if possible. Where Type I and II mixes are used longitudinal joints should hardly be visible at all. Longitudinal joints may be either butted or overlapped, with any overlap not exceeding 75 mm (3 in) (FHWA 2002).

Rolling is usually not necessary for slurry seals placed on roadways. In some cases, rolling may help to improve slurry performance by increasing aggregate embedment. It is also recommended for some rut filling operations, and is occasionally used later in the season to help to remove moisture from the mix. A common 9 to 11 metric ton (10 to 12 English ton) nine-wheel pneumatic-tired roller with 350 to 425 kPa (50 to 60 psi) tire pressure is adequate, and two passes of the roller are generally sufficient (TAI 1997). It is important to roll when the slurry seal is set enough to support the roller without having material pick up on tires (TAI 1997). Steel-wheeled rollers are not appropriate for slurry seals as these rollers tend to bridge the high spots on the pavement and fail to compact the pavement in the low areas; these rollers can also mark the surface and could crush the larger aggregate (TAI 1997).

7.3.3.2 Microsurfacing

Microsurfacing is mixed and placed using specialized, compartmented, self-powered trucks (TAI 1997). The mixing chamber on this equipment consists of a double shafted, multi-bladed pugmill that thoroughly mixes the materials. The semi-fluid microsurfacing mixture falls into an augured screed box and is deposited on the pavement across a full lane width as the truck moves forward on the roadway (TAI 1997). Continuous laydown microsurfacing trucks are supplied with aggregate and asphalt emulsion by “nurse” trucks and are capable of producing up to 450 metric tons (500 English tons) of microsurfacing per day (TAI 1997).

Microsurfacing may be used to fill ruts, provided that the ruts are not experiencing continued densification. Rut filling generally requires the use of a rut filling box (required for pulling ruts over 12 mm [0.5 in] deep). The width of the rut box is typically about 1.5 to 1.8 m (5 to 6 ft) wide in order to adequately fill the rut, and one wheel path is filled at a time. Ruts should be overfilled to compensate for additional traffic compaction; recommended guidelines for overfilling are 1.2 to 2.4 mm/cm (0.125 to 0.25 in/in) of rut depth. While Type III mixes are recommended for rut filling, for ruts greater than 32 mm (1.25 in) deep, two lifts are recommended. Multiple rut filling passes can correct depressions in excess of 50 mm (2 in) in depth (TAI 1997).

As with slurry seals, care should be taken to avoid overloading the spreader and excessive buildup of microsurfacing at longitudinal and transverse joint lines should be prevented. Longitudinal joints may be either butted or overlapped, with any overlap not exceeding 75 mm (3 in) (FHWA 2002).

Rolling is rarely required for microsurfacing as vehicular traffic normally provides adequate compaction (TAI 1997). When rolling is required, the same roller types and number of passes described above under the slurry seal construction section are appropriate for microsurfacing as well. As with slurry seals, it is important to roll when the slurry seal is set enough to support the roller without having material pick up on tires (TAI 1997). Steel-wheeled rollers are also not appropriate for microsurfacing as these rollers tend to bridge the high spots on the pavement (failing to compact the pavement in the low areas) and they can mark the surface and crush the larger aggregate (TAI 1997).

7.3.4 **Handwork**

Handwork is required on both slurry seals and microsurfacing to spread the material in areas that can not be reached by the spreader box, improve joints, and correct minor imperfections. Handwork is accomplished with either a squeegee or a drag mop, moving in the same direction as the surfacing operation (if drag mops are used on the spreader box then they should also be used on the squeegee to match the texture). Mops are used to smooth out the joints, especially on more fluid mixes. As with any paving job, the less handwork the better the result. Excessive handwork can segregate the mix as well as leave an unsatisfactory finish. Those who do handwork are the last people to touch the mix and have the largest impact on the final product, so these personnel should be well trained in what they do.

7.3.5 Opening to Traffic

As should be clear from the preceding discussion of the many variables that affect slurry performance, the time until the resurfaced pavement can be opened to traffic is variable. The primary factor affecting this is environmental conditions, especially for slurry seals. Under most conditions, microsurfacing breaks in 1 to 2 minutes and can carry traffic after approximately 1 hour. Slurry seals may require from 2 to 4 hours before being able to carry traffic, although quick setting emulsions may be able to carry traffic in as little as 1 hour. The timing of applying pavement markings also depends on environmental conditions. The key to the timing is the cure time: all water must be gone from the pavement before pavement markings are applied. In a hot, dry environment that might occur in as little as 24 hours, while in a more humid environment it could take from 72 hours to 1 week.

7.4 STOCKPILE MANAGEMENT

Stockpiling is a storage method that assures material availability and permits the contactor to respond effectively to fluctuating market demands[1].

Stockpile areas are generally used to store materials and equipment that will be used on the project and must meet some basic requirements. This would include the following:

- A clean, well drained pad for aggregate
- A screening plant to remove oversize material and contaminants before loading aggregate to be delivered to the mixing machine
- Proper equipment for loading hauling units
- A potable water supply
- Storage for emulsion and additives

The stockpile should be as close to the project site as is possible since delivery of aggregates to the stockpile site must be dependable, flexible, and adaptable to peak load demands.

Stockpiling of aggregate is extremely important in producing a uniform slurry system. Variation in grading, due to segregation, and uneven moisture content can be a major cause for the lack of uniformity in the mixture. It is a fact that emulsion demand is influenced by the coarseness or fineness of the gradation. A constantly fluctuating gradation makes control virtually impossible and results in extreme variations in product quality[2] . The three most common problems when building stockpiles are segregation, degradation, and contamination[1].

Segregation can be minimized by building the stockpile in reasonably thin layers Dense graded aggregate, like those used in slurry and microsurfacing, tend to segregate more readily than single size or gap graded aggregate. Segregated stockpiles can be re-worked with a front end loader operated by an experienced operator.

A typical stockpile site can be seen in Figure 7.4.

FIGURE 7.4 Typical stockpile site.

7.5 MIX DESIGN VERIFICATION

7.6 TROUBLESHOOTING

So far, this chapter has focused on the construction of quality slurry surfacings. However, in any construction project there is always something that can go wrong, even when all of the proper preparations have been made. This section identifies the causes and solutions to some of the common problems that are seen in slurry projects.

7.6.1 Stripes or Drag Marks

These are caused by oversized aggregate or material that's already broken which falls off the machine and gets stuck in the spreader box. When the drag mark is in a slurry seal, it can be fixed if a worker is within 3.0 to 3.7 m (10 to 12 ft) of the mark. With microsurfacing, anything that is visible after the secondary strike-off is going to still be there. Where there is a drag mark or foreign object, it is best just to leave it alone. The potential for drag marks can be reduced by screening aggregate at the stockpile to eliminated oversized material. Keeping the primary strike-off free of material build-up also is helpful.

7.6.2 Uneven Free Edge

Too much water in the mix allows the edge to run. This is not only an aesthetic problem, but has a high potential for subsequent raveling. This problem is corrected by either not adding excess water or by removing some of the water from mixes that run.

7.6.3 Mixes That Break Too Soon or Too Late

Mixes that don't break as intended are a cause for immediate concern. Troubleshooting areas of interest include verifying that the materials in the mix design have not changed and checking environmental conditions to make sure that they are still appropriate for paving. When the mix is not behaving as intended, paving should stop until the cause of the problem is identified and a solution is implemented.

7.6.4 Tire Damage

Despite advance notice and signage, there is always the possibility of drivers getting onto an uncured slurry. The appropriate repair is to reapply slurry with the paving machine. Some contractors will use extra cones to try to keep traffic off of the street.

7.6.5 Chatter and Ripple Marks

This condition has a negative effect on the ride, but is usually avoidable. The marks are commonly caused by the paving equipment moving too fast and not using a secondary strike-off. This should be corrected immediately by slowing down the rate of placement and having the proper secondary strike-off set up.

7.6.6 Joint Raveling

Raveling can be caused by applying too much water to the longitudinal joint. Reducing the application of water used in finishing the longitudinal joint will reduce this potential. Raveling may also be the result of the mix breaking or curing too slowly, or traffic being allowed on the pavement before the emulsion is properly set.

7.6.7 Delamination

Delamination will occur when there is not a good bond between the underlying pavement and the slurry. All surface contaminants, such as dust, loose aggregate, or any material that will prevent bond should be removed prior to paving. Additional guidance on surface preparation is provided above.

CHAPTER 8 QUALITY CONTROL

The process of QC on a slurry job does not start when construction begins. The first QC task is to make sure that the project is a good candidate for a slurry by following the previously presented guidance on project selection and pavement repair. The steps associated with mix design are also very important. Materials used in the slurry should be of the highest quality affordable, and a mix design must be prepared using the same materials that will be used on the job. The emulsions should be tested to verify that they are the type specified in the design; a *Certificate of Compliance* from the asphalt supplier is necessary insurance. Some agencies are also requiring the aggregate supplier to certify the aggregates that are being shipped, rather than just the quality of the source.

As with most projects in which a contractor is working for an owner agency, the project will have the best outcome if the agency and the contractor work together as a team. Both should be familiar with the project specifications, and have a clear understanding of the desired results. The field inspector and the contractor's foreman should have the authority to make the necessary field decisions required to obtain a quality product, and maintain open lines of communication. While the agency inspector is usually responsible for monitoring construction quantities and quality, both should keep accurate records and meet daily to review quantities.

The industry has organized important elements of QC for slurry surfacings in the following publications: *AV-6, Emulsified-Asphalt Slurry Seal (Quality Control)—SA-3 A Guide to Quality Construction* (ISSA 2001a), *SA-6 Microsurfacing: Quality Assurance and Use Guidelines for Microsurfacing* (ISSA 2001b), and a new QC checklist developed by the Federal Highway Department (FHWA 2002). The remainder of this section looks at many of the detailed items that should be included as part of a comprehensive QC plan.

8.1 PRELIMINARY RESPONSIBILITIES

Preliminary responsibilities are those QC tasks that are performed prior to arriving on the construction site. Generally, these activities may be further categorized as project review, document review, and material checks.

8.1.1 Project Review

The first QC task is to make sure that the project is a good candidate for the selected treatment. The guidelines outlined in the "Description" section of this module may be used to answer this question. Specific questions that should be asked as part of this review include (FHWA 2002):

- What types of rutting and cracking is present?
- Severity and extent? Is crack sealing needed?
- How much bleeding or flushing exists?
- Is the pavement raveling?
- What is the traffic level?
- Is the base sound and well drained?
- Does this project require that the work be completed at night?
- Review project for bid/plan quantities.

8.1.2 Document Review

Before arriving on the construction site, it is important for the contractor to understand all of the documents and specifications associated with the seal coat or rejuvenator project. Therefore, a comprehensive QC plan should include scheduled reviews of bid specifications and special provisions, mix design information, the construction manual, the proposed traffic-control plan and requirements, manufacturers' instructions, and the material safety data sheets (MSDS).

8.1.3 Materials Checks

Significant attention should be given to make sure that the most appropriate materials are selected for use on a project. As part of the QC plan, the contractor should review the material selection and preparation processes by ensuring that (FHWA 2002):

- A full mix design has been completed.
- All necessary compatibility tests have been completed.
- The emulsion is from an approved source (if required).
- The emulsion is sampled and submitted for testing (if required).
- The emulsion temperature is within specified application temperature requirements.
- The aggregate is clean, dry, free of deleterious materials, and meets all agency specifications.
- There are no signs of segregation in the aggregate stockpile.
- There are no signs of contamination when the aggregate stockpile is in use.

8.2 PRE-APPLICATION INSPECTION RESPONSIBILITIES

Pre-application responsibilities are those items that should be conducted on the job site prior to conducting the joint sealant process. These activities include an inspecting the prepared surface, conducting equipment inspections, reviewing weather requirements, checking application rates, and reviewing the implemented traffic control plan. Detailed activities within each of these categories are presented below.

8.2.1 Surface Preparation

Prior to the application of the chosen treatment, the surface should be inspected to ensure that it is clean and dry. Also, the inspector should verify that all existing distress that was required to be repaired was actually repaired.

8.1.2 Equipment Inspections

At the beginning of each day, the contractor should make sure that the equipment is in good mechanical condition. For example, all equipment should be free of leaks, calibrated, and clean. More specific equipment inspection recommendations include the following (FHWA 2002):

- <u>Brooms</u>. The brooms used to clean the pavement surface should be inspected to make sure the bristles are of proper length and in good condition, and that the vertical pressure on the broom can be adjusted.
- <u>Paving equipment</u>. The specialized slurry seal or microsurfacing equipment should be inspected to make sure that the equipment is fully functional and calibrated. Important components such as screeds, spreader rubbers, pugmill paddles should be inspected to make sure that they are clean and not worn. The spreader box should be inspected to ensure that it is clean and of the correct type.
- <u>Rollers (if used)</u>. If required, rollers should be inspected to ensure that they meet all agency requirements (i.e., roller type, weight, roller tire size, tire pressures, and so on).

8.2.3 Weather Requirements

At the beginning of each day, the expected weather conditions should be compared to those conditions specified as being acceptable for construction. In general, the following weather-related guidelines should be considered (FHWA 2002):

- The inspector should ensure that air surface temperatures have been checked at the coolest location on the project, and that these observed temperatures meet agency requirements.
- The application of the emulsion should not begin if rain is likely or if overnight temperatures could be at or below freezing.
- High temperatures, humidity, and wind will affect how long the emulsion takes to break.

8.2.4 Traffic Control

Prior to the setup of traffic control, the contractor should ensure that all signs and devices match those outlined in the traffic control plan. Also, the setup should be inspected to ensure that it complies with the local agency specifications or the Federal Manual on Uniform Traffic Control Devices (MUTCD) (FHWA 2002).

8.3 PROJECT INSPECTION RESPONSIBILITIES

General project inspection QC activities include inspections of the treatment application process, rolling procedures (if necessary), truck operation, and joint forming are discussed in this section. Also included are QC considerations associated with opening the pavement to traffic and night work.

8.1.3 Treatment Application

During the application of the slurry seal or microsurfacing treatment, the following activities should be included as part of a comprehensive QC plan (FHWA 2002):

- Verify that a test strip been completed and that it is satisfactory.
- Confirm that field tests have been carried out and they are in the specification.
- Building paper should be used at the starting and stopping points of the treatment to create straight edges.
- Verify that enough trucks are on hand to keep a steady supply of material to the paving process.
- The paving machine should take a straight even line with minimal numbers of passes to cover the pavement.
- Conduct visual inspections of the finished product to make sure that the final surface is even, uniform, and free of drag marks from oversize aggregate or dirty equipment.
- Check the application rate based on the amount of aggregate and emulsion used.
- Check that the equipment is properly maintained and cleaned at the end of each day.
- The following are inspection activities specific to microsurfacing:
    - A rut box should be used for ruts deeper than 12 mm (0.5 in).
    - A leveling course is used with a steel strike-off for ruts less than 12 mm (0.5 in) deep.
    - Two courses are used where rut filling or leveling is employed.
    - Stop the application and make necessary adjustments if any problems are observed.

8.3.2 Rolling (if applicable)

If rolling is found to be required, the rolling process should not be allowed to begin until the mat is stable. Rolling should begin at one edge and move to the other edge in a run, taking care to roll the joint (FHWA 2002). Roller speed should be closely monitored to ensure that they travel less than a maximum speed of 8 km/hr (5 mph).

8.3.3 Truck Operation

The operation of trucks at the job site should be monitored so ensure that practices are being used that will not damage the freshly placed treatment. Trucks should travel slowly, make stops and turns gradually to avoid damaging the mat, and be staggered across the fresh treatment to avoid driving over the same area.

8.3.4 Joint Forming

The formation of longitudinal joints should be monitored to make sure that meet lines are not made in the wheel paths (FHWA 2002). Meet lines should be made at the center of the road, center of the lane, or edge of a lane. Adjacent passes should only be allowed to overlap a maximum of 75 mm (3 in).

8.3.5 Opening to Traffic

Until the treatment is given adequate time to cure, traffic on the treatment must be closely monitored. Ideally, a pilot car should be used to control traffic speed (kept below 40 km/hr [24 mph]) on the fresh treatment until it is deemed acceptable to open to normal traffic. If pilot cars are not an option for the project, reduced speed limit signs should be used.

If a quality job is being constructed but the public is not kept informed of the work, the project can cause as much dissatisfaction as if it were done poorly. All businesses and residences should be notified of the work before it is performed, such as through door hangars describing the slurry process and announcing the date and time of the work. As part of this notification process, it is probably a good idea to describe the benefits of the treatment.

Residents should be informed that while the slurry is still wet, any movement on it will damage the surface. In most cases, street parking will be prohibited for a day. While providing notice 24 hours ahead of time is typical, in some cases it will not be enough. All notices should be placed where people will see them. An extra effort to communicate with residents will help to ensure a successful placement.

8.3.6 Night Work

In many areas, microsurfacing is done at night to avoid disrupting traffic. From a performance viewpoint, night work is problematic for slurry seals because the temperatures may not allow the material to cure as rapidly as needed (but should not be a problem for microsurfacing, which cures chemically). Night work is difficult, as it is for any night paving operation, because the ability to see problems in the mat is greatly diminished. Where there are problems, they may not be visible until a daytime inspection, at which time removal may be the only viable option.

Safety is also a greater problem with night work; both the safety of the construction team and the traveling public are at greater risk, and every precaution should be taken to ensure that the proper signage is in use and visible and that all workers are wearing proper reflective safety gear. Regular safety briefings can help to reinforce the fact that safety is the responsibility of all who work on the project.

CHAPTER 9 REFERENCES

CHAPTER 10 APPENDICIES

10.1 TEST PROTOCOLS

CHAPTER 11 GLOSSARY OF TERMS